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(71) Applicant *(for all designated States except US):* A.G.(PATENTS) LIMITED [GB/GB]; 24 Portland Place, London W1N 4BB (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only) :* McKEOWN, Michael, Peter [GB/GB]; 50 Brayfield Road, Littleover, Derby DE3 6GT (GB).

(74) Agent: DAVIES, Christopher, Robert; Frank B. Dehn & Co., Imperial House, 15-19 Kingsway WC2B 6UZ (GB).

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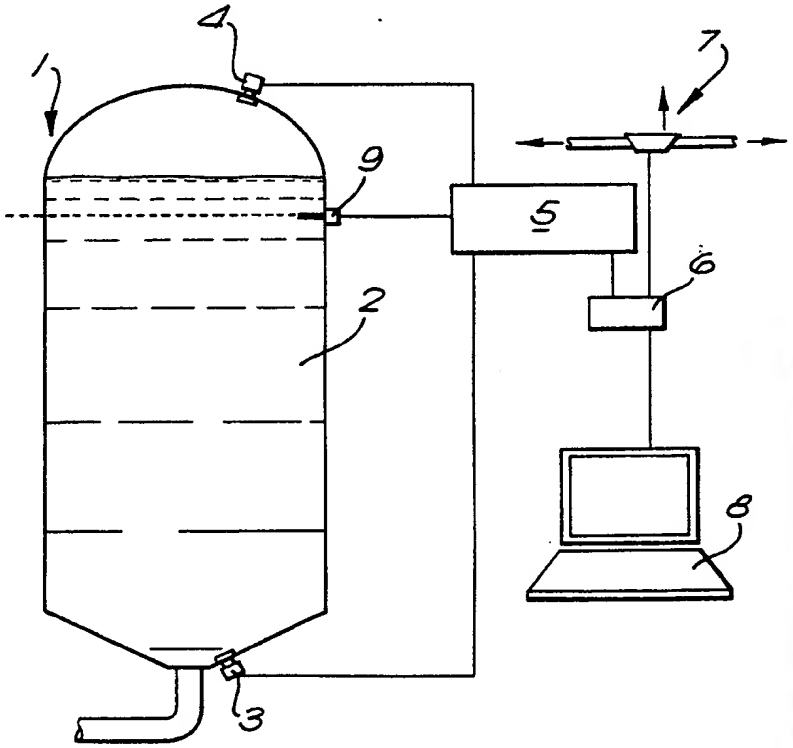
(54) Title: FLUID PRESSURE OPERATED VOLUME MEASUREMENT WITH LEVEL CALIBRATION MEANS

(57) Abstract

Apparatus for measuring the volume of liquid (2) in a vessel (1) such as a post-fermentation tank comprises, a pressure detector (3) for measuring the pressure of the liquid at the base of the vessel, a pressure detector (4) for measuring the pressure at the top of vessel, processing means (5, 6, 7) for establishing an estimated volume of liquid in said vessel based on the outputs of said pressure detectors (3, 4), and correcting means including a level detector (9) for detecting when the level of liquid in said vessel reaches a predetermined level corresponding to a known volume, and means (5, 6, 7) for generating a correction factor to be applied, if necessary, to the estimated volume by comparing the estimated volume when the level of liquid reaches said predetermined level with the known volume corresponding to said predetermined level.



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FLUID PRESSURE OPERATED VOLUME MEASUREMENT WITH LEVEL CALIBRATION MEANS

This invention relates to the measurement of the volume of liquid in a vessel, especially, but not exclusively, in the context of the brewing industry.

It is often necessary to know the quantity of liquid in a closed vessel, for example a post-fermentation tank, where direct inspection of the liquid is not possible. One known method of indirectly measuring the volume of liquid in such a vessel is to measure the pressure of the liquid at the bottom of the vessel and the pressure at the top of the vessel. From these pressure measurements, and making correction for the specific gravity of the liquid and the shape of the vessel, the volume of liquid in the vessel can be calculated. However, this method is prone to errors. For example, the calibration of the pressure detectors may drift, or the actual specific gravity of the liquid in the vessel may differ from the theoretical value used in the calculations.

According to the present invention there is provided apparatus for measuring the volume of liquid in a vessel comprising, means for measuring the pressure of the liquid at the base of the vessel, means for measuring the pressure at the top of said vessel, processing means for establishing an estimated volume of liquid in said vessel based on the outputs of said pressure measuring means, and correcting means including means for detecting when the level of the liquid in said vessel reaches a predetermined level corresponding to a known volume, and means for generating a correction factor to be subsequently applied, if necessary, to the estimated volume by comparing the estimated volume when the level of liquid reaches said predetermined level with the known volume corresponding to said

predetermined level.

By means of this arrangement, when the vessel is either being filled or emptied and the liquid reaches the level sensed by the detecting means, the calculated liquid volume can be compared with the actual value. If the two values differ a correction factor can be generated which can be applied to subsequent calculations.

Possibly, in order to increase the accuracy of the system, detecting means may be provided at a number of levels corresponding to different known volumes. In this way the correction factor can be updated frequently.

In a preferred embodiment means may be provided for generating an alarm signal when the calculated liquid volume when the liquid is at the predetermined level is greater than and/or less than the known volume by more than a preset limit or preset limits. For example, an alarm signal may be generated when the calculated and actual values differ by more than ± 1%, indicating that the system needs checking and that, perhaps, the pressure detectors may need re-calibrating.

Preferably the calculation may be carried out by a computer system including a programmable logic controller. The computer system may have access to 'look up' tables from which volume values can be read for given pressure measurements. The computer system may also have access to prestored values of the specific gravity for different liquids in order to be able to generate an appropriate specific gravity correction factor. Alternatively the specific gravity may be entered manually if desired.

According to another aspect of the present invention there is provided a method of measuring the volume of liquid in a vessel comprising, measuring the liquid pressure at the base of the vessel, measuring the pressure at the top of the vessel, establishing an

estimated volume of liquid from said pressure measurements, and applying, if necessary, a correction factor to said estimated volume, said correction factor being generated by comparing the estimated volume with a known volume when the liquid reaches a predetermined level.

As has been mentioned previously, the present invention is particularly applicable to the brewing industry but is not limited thereto and many other applications may be envisaged.

An embodiment of the invention will now be described by way of example and with reference to the accompanying drawings in which:-

Fig. 1 is a schematic view of apparatus according to an embodiment of the invention, and

Fig. 2 is a block diagram showing the calculation method.

Referring firstly to Fig. 1 there is shown, schematically, a liquid vessel 1 such as a post-fermentation tank, containing a body of liquid 2. The vessel 1 is provided with a first pressure detector 3 at the base thereof, while a second pressure detector 4 is provided at the top of the vessel. The first pressure detector measures the pressure exerted by the head of liquid plus the pressure of any gas (e.g. CO_2) above the liquid 2. The second pressure detector 4 measures only the pressure at the top of the vessel, i.e. the pressure of the gas.

The outputs of the two pressure detectors 3, 4 are fed to a programmable logic controller (PLC) 5 where the analogue inputs are converted to give pressure readings. The PLC 5 is operatively connected via an interface unit 6 to the site computer network 7 and an operator terminal 8.

The liquid vessel 1 is also provided with a level detector 9. The level detector 9 is arranged to provide an output signal to the PLC 5 when the liquid level

reaches a predetermined point (either when emptying or filling the vessel 1). The predetermined level is chosen to correspond to a previously measured known volume, for example 1000 barrels. The level detector 9 is used to generate a calibration or correction signal in a manner that will be described further below.

To calculate a volume measurement for the volume of liquid in the vessel, the steps shown schematically in Fig. 2 are followed. The outputs of pressure detectors 3, 4, corresponding to the bottom and top pressure respectively, are fed to the PLC 5 where they are converted to engineering units and passed on to the site computer network 7. Within the computer network 7 the necessary calculations are performed to obtain the volume measurement.

Firstly, the top pressure reading is subtracted from the bottom pressure to give a value corresponding only to the pressure generated by the head of liquid. This pressure differential, corresponding to the liquid head pressure, is then divided by the theoretical specific gravity of the liquid concerned in order to compensate for the different specific gravities of different liquids.

The resulting value is then compared with values in 'look-up' tables stored in the computer system. The look-up tables are prepared by previously measuring the pressure readings obtained with known volumes of liquid. The calibration of the vessel may be achieved using a precision flowmeter. The liquid head being measured with the "dip" tape every 10 barrels up to the 100 barrel level and at 100 barrel intervals thereafter. A separate look-up table is created for each type of vessel since the shape of the vessel is a factor that must be taken into account. As an alternative to using look-up tables, it may be possible to calculate directly an estimated volume from the present readings using an appropriate algorithm. After obtaining a theoretical

or estimated volume measurement from the 'look-up' tables, a correction factor is applied to produce an actual volume measurement that may be displayed, along with other information such as the pressure readings and correction factor, on the operator terminal 8. The correction factor is obtained by comparing the calculated volume with the actual volume when the level of liquid reaches a known level, indicated by a level detector, as the vessel is filled. For example, if the known volume at which the level detector is set is 1000 barrels, but the system calculates a volume of 1005 barrels, then there exists an error of - 0.5% which must be applied to all subsequent volume calculations. The error can be checked as the liquid in the vessel is emptied and reaches the predetermined level. By applying such an error correction factor to the calculated result, account can be taken of such error inducing problems as drifting of the calibration of the pressure detectors, or variations in the specific gravity of the liquid from the theoretical value used in the calculations. If the error exceeds a predetermined limit or predetermined limits in either direction, e.g. ± 1%, the system may be configured to generate an alarm to this effect to advise an operative that the system needs checking and/or renewing.

Claims

1. Apparatus for measuring the volume of liquid in a vessel comprising, means for measuring the pressure of the liquid at the base of the vessel, means for measuring the pressure at the top of said vessel, processing means for establishing an estimated volume of liquid in said vessel based on the outputs of said pressure measuring means, and correcting means including means for detecting when the level of the liquid in said vessel reaches a predetermined level corresponding to a known volume, and means for generating a correction factor to be subsequently applied, if necessary, to the estimated volume by comparing the estimated volume when the level of liquid reaches said predetermined level with the known volume corresponding to said predetermined level.

2. Apparatus as claimed in claim 1, wherein said correcting means includes detecting means provided at a plurality of predetermined levels corresponding to different known volumes.

3. Apparatus as claimed in claim 1 or 2, wherein there is provided alarm generating means for generating an alarm signal when the estimated liquid volume at a predetermined level is greater than and/or less than the known volume at said predetermined level by more than a preset limit or preset limits.

4. Apparatus as claimed in any preceding claim, which includes a computer system having a programmable logic controller for calculating said liquid volume.

5. Apparatus as claimed in claim 4, wherein volume values corresponding to given pressure measurements are prestored in said computer system.

6. Apparatus as claimed in claim 4 or 5, wherein specific gravity values for a plurality of liquids are prestored in said computer system.

7. Apparatus as claimed in claim 4 or 5, wherein there is provided means for manually entering specific gravity values into said computer system.

8. A method of measuring the volume of liquid in a vessel comprising, measuring the liquid pressure at the base of the vessel, measuring the pressure at the top of the vessel, establishing an estimated volume of liquid from said pressure measurements, and applying, if necessary, a correction factor to said estimated volume, said correction factor being generated by comparing the estimated volume with a known volume when the liquid reaches a predetermined level.

9. A method as claimed in claim 8, wherein a correction factor is generated at a plurality of predetermined liquid levels.

10. A method as claimed in claim 8 or 9, wherein an alarm signal is generated when the estimated volume at a predetermined level is greater than and/or less than the known volume at said predetermined level by more than a preset limit or preset limits.

11. A method as claimed in any of claims 8 to 10, wherein said liquid volume is calculated using a computer system having any of the features of claims 4 to 7.

1/2

FIG. 1

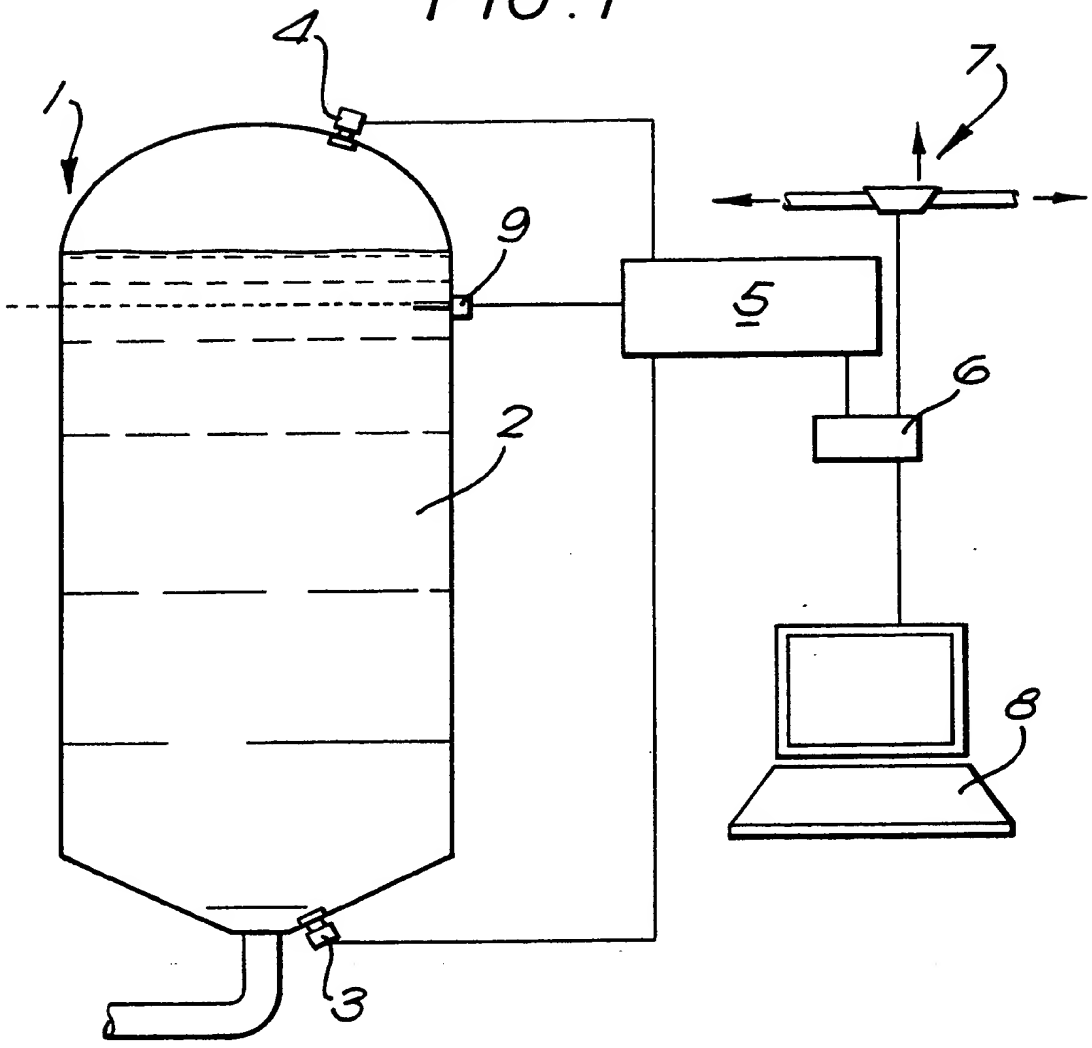
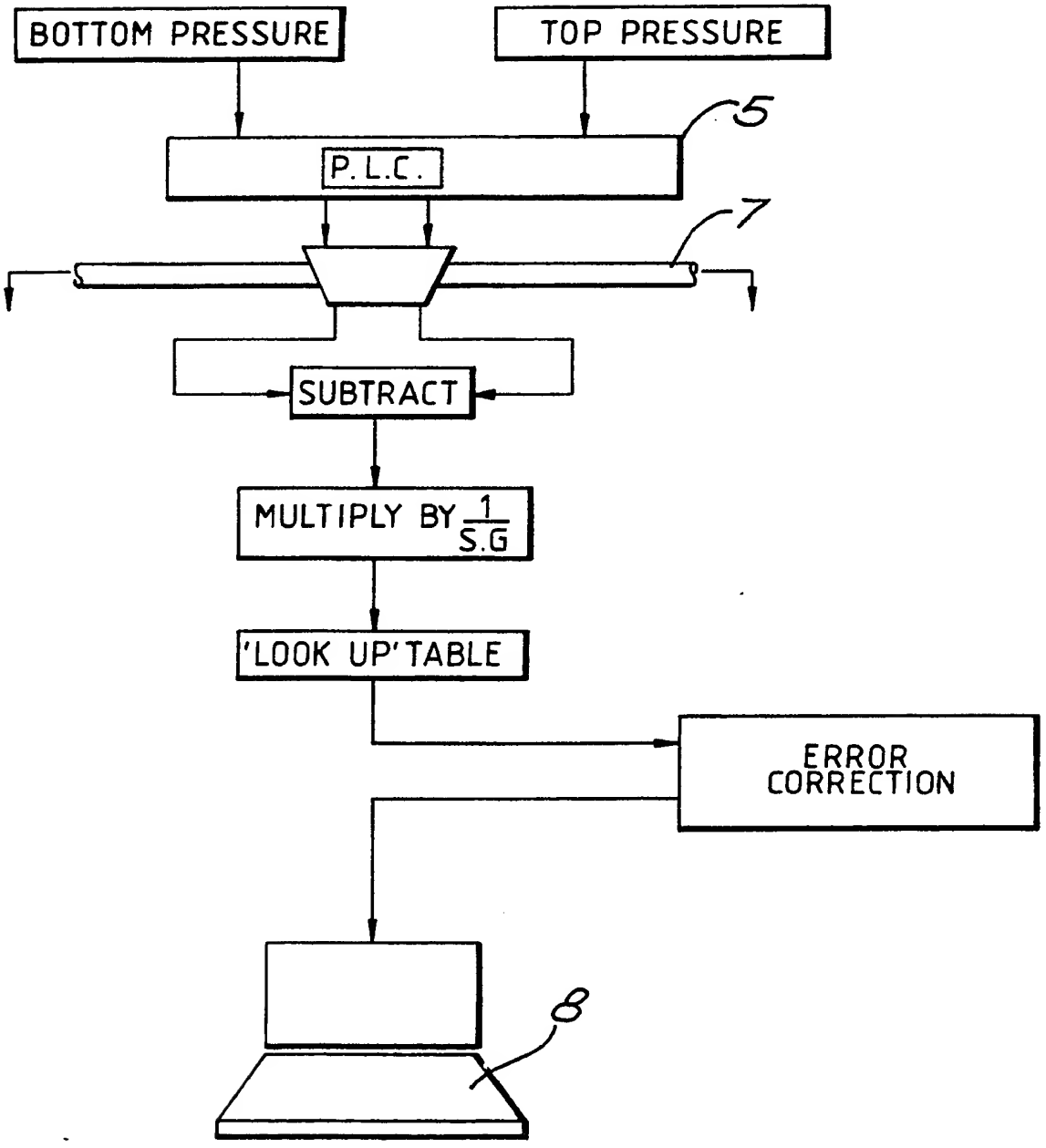


FIG. 2



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00768

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.5 G 01 F 23/14 G 01 F 23/18 G 01 F 25/00

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl.5	G 01 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	ADVANCES IN INSTRUMENTATION AND CONTROL, vol. 44, part 4, 1989, (Research Triangle Park, NC, US), W. OGLESBY: "A comparative analysis: Volume and mass derived from tank gauging systems", pages 1493-1504, see page 1493, last paragraph - page 1495, last paragraph; figures 4-7	1,4,5,7 ,8,11
Y	---	1-4,8, 10
X	GB,A, 256289 (MARTIN) 4 August 1926, see page 4, line 104 - page 6, line 119; figure 1	1,8
Y	--- GB,A,2138947 (CHILTERN GLASS FIBERS) 31 October 1984, see page 1, line 5 - page 2, line 9; page 4, line 48 - page 5, line 24; figures 2,4,5	1-4,8-10

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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
31-07-1991	27. 09. 91
International Searching Authority	**Signature of Authorized Officer**
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ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. GB 9100768

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 256289		None	
GB-A- 2138947	31-10-84	US-A- 4598742	08-07-86